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Cumulative index & abridged abstracts, volumes 16–20

Abstracts of articles

1 *Computers and the emancipation of students: giving control to the learner,* 16(1987), 3–18 Laurillard, D.

The 'didactic' and 'communication' models of the teaching-learning process are considered. It is demonstrated that CAL has generally embodied a didactic model, which imposes an unnecessary restriction on the student's freedom to choose a learning style. The author then discusses how it is possible for CAL to support a less didactic model.

2 *The new Component Design Theory: instructional design for courseware authoring,* 16(1987), 19–34 Merrill, M. D.

The new Component Design Theory provides the type of design guidance needed for experiential computer based instructional systems. A set of cardinal instructional principles is identified and the sets of rules which comprise the new CDT are suggested as prescribed procedures for implementing these principles.

3 *Implications for instruction arising from the relationship between approaches to studying and academic outcomes,* 16(1987), 35–46 Kember, D. & Harper, G.

This study used the Approaches to Studying Inventory on a sample of 1095 students. Discriminant analyses were performed using the subscale scores as discriminating variables, and these distinguished significantly between those who persisted with a course and those who withdrew or failed, surface approach being the major discriminator.

4 *Double-coding: a key to knowledge utilization and generation in the instruction and learning of skills,* 16(1987), 47–58 Martin, J.

Double-coding refers to the simultaneous holding in declarative and procedural memory stores of information concerning the performance of a skill. Skill acquisition typically terminates in a stage of automatisation during which declarative coding of skill-relevant information is lost or becomes irretrievable. It is argued that maintenance of both declarative and procedural knowledge relevant to skills and their performance permits unique metacognitive capabilities.

5 *Instructional design and intelligent systems: shifts in the designer's decision-making role,* 16(1987), 59–77 Winn, W.

In intelligent instructional systems, it is possible to shift certain aspects of decision-making back to the implementation phase of instruction. This enables systems to adapt to changing conditions and to present information in a variety of formats. The designer becomes less concerned with selecting methods and puts more effort into writing rules that allow systems to select methods once instruction has begun.

6 *A comparative study on the use of humor in the design of instruction,* 16(1987), 79–100 Vance, M.

This study examined the effects of three integrated and contiguous instructional designs using incongruity humor on the recognition and recall of information measured by immediate learning and retention tests. The two contiguous humor treatment groups had higher immediate memory and retention scores than the control group, particularly with regard to the control of new information.

7 *The knowledge base for instructional design,* 16(1987), 105–108 Warries, E.

The ethnomethodological programme of 'studies of work' is drawn on to provide a general framework within which we might develop ways to undertake the *in situ* analysis of the competencies which constitute student learning activities. The objective of such research is to describe the locally managed and temporally organised nature of student learning work.

8 *Causal attribution by sensing and intuitive types during diagnostic problem solving,* 16(1987), 123–136 Boreham, N. C.

Attempts by sensing and intuitive types to diagnose a malfunctioning industrial system by operating a computer-based data bank were compared. Intuitives made significantly more causal attributions to factors lying behind the immediately perceived malfunction. The various implications of these findings are then discussed.

9 *A method for sequencing instructional objectives which minimizes memory load,* 16(1987), 137–150 Nesbit, J. C. & Hunka, S.

An alternative is described here to traditional methods of choosing between sequences of instructional objectives. For every sequence a memory load value can be calculated, and an algorithm presented which generates a minimal memory load sequence from a learning tree. The algorithm was applied to several published examples of learning hierarchies and was judged to be effective.

10 *Developmental theory in the classroom,* 16(1987), 151–167 Smith, L.

The role of developmental psychology in the understanding of classroom learning and teaching raises two questions: does a developmental perspective provide an adequate basis for a theory of the classroom; and what is the utility to teachers of the adoption of such a perspective. Several examples of the application of a developmental perspective are discussed and some conclusions are drawn.

11 *Computer conferencing and the humanities,* 16(1987), 169–186 Feenberg, A.

This paper offers an account of various aspects of on-line teaching based on a humanities teacher's personal experience with several on-line seminars. The paper uses concepts from communications theory to explain the features of computer conferencing most important to teachers in organising on-line classes.

12 *Learning schemata: methods of representing cognitive, content and curriculum structures in higher education,* 16(1987), 187–211 Donald, J. G.

Being able to represent knowledge is a key to being able to utilize it. Examination of the methods used to represent cognitive, content and curriculum structures leads to suggestions for their use in clarifying the learning task.

13 *Enhancing children's thinking skills: an instructional model for decision-making under certainty,* 16(1987), 215–231 Beyth-Marom, R., Novik, R. & Sloan, M.

In a dynamic society, the teaching of facts becomes less vital while the teaching of thinking skills turns out to be indispensable. Educators have recognised the need for curricula devoted to thinking skills in general and attempts to attain this goal have already been made. However, almost no attention has been given to teaching children the skill of decision making under certainty and this paper proposes a framework for developing school material to cultivate such skills.

14 *Notetaking and review: the research and its implications,* 16(1987), 233–249 Kiewra, K. A.

Notetaking and review are positively related to academic achievement, but many students record too few notes to benefit fully from these activities. This paper presents ten factors that may constrain notetaking and review, and provides corresponding implications for improving these study behaviors and for conducting further research.

15 *Instructional strategies and tactics for the design of introductory computer programming courses in high school,* 16(1987), 251–285 van Merriënboer, J. G. & Krammer, H. P. M.

This article offers an examination of instructional strategies and tactics for the design of introductory computer programming courses in high school. We distinguish the Expert, Spiral and Reading approaches as groups of instructional strategies that mainly differ in their general design plan to control students' processing load. We distinguish between declarative and procedural instruction and and present six tactics which can be used to design courses and to evaluate strategies.

16 *Effects of audiovisual stimuli on learning through microcomputer-based class presentation*, 16(1987), 287–306 Hativa, N. & Reingold, A.

This study examined the differential effects of color, animation and non-verbal sounds incorporated into microcomputer software, on the learning of geometric concepts. The stimulus version of the software used all three audiovisual factors as one cueing factor. The no-stimulus version presented the same screen display except in monochrome with no animations or sound. Results revealed significantly better immediate and delayed learning of the stimulus group.

17 *Developmental theory and teachers' practice*, 16(1987), 307–317 Smith, L.

Do teachers have to use developmental theory? It is argued in this paper that the specific character of teacher practice has yet to be explored systematically. Three different interpretations of the notion of development are shown to be present in recent educational discussions. Reflective practice is necesary for their elaboration and evaluation.

18 *Artificial intelligence tools for grammar and spelling instruction*, 16(1987), 319–336 Pijls, F., Daelemans, W. & Kempen, G.

Grammar teaching is an especially important subject in the curriculum of children aged 10-15 in the Netherlands. However, results are poor in spite of the time and attention invested. This article describes the problems and the authors' attempts to overcome them by developing an intelligent computer-based instructional environment.

19 *Understanding Turn commands in Logo: a cognitive perspective*, 16(1987), 337–350 Geva, E. & Cohen, R.

Many young children experience difficulties using the right and left turn commands in Logo. This paper looks at the spatial concepts required, and examines the psychological-cognitive literature on the development of spatial concepts. Children need to master a set of prerequisite skills, and to be exposed to Logo programs designed to facilitate the development of spatial concepts which would enable the successful progression to more complex Turtle Geometry programming tasks.

20 *Confronting dynamics misconceptions*, 16(1987), 351–379 Brna, P.

This paper starts from the assumption that learning is promoted through confronting students with the inconsistencies entailed by their own beliefs. This issue is explored in the domain of Newtonian dynamics in the context of one or more moving particles. Previous work is used as the basis for the construction of a programme of work which entailed the development of a computer-based modelling environment. The results derived from observation suggest that computer-based modelling facilities can provide advantages over approaches exploiting other media.

21 *Consequences of Costa Rican teachers' attributions for students' failure*, 16(1987), 381–387 Rodriquez, R. & Tollefson, N.

A sample of elementary teachers in Costa Rica rated their expectancy of success, willingness to help, liking for, and evaluation of two students who were failing: one because of low ability, one because of insufficient effort. Significantly higher mean ratings on all four consequences were observed for the proocol describing the student who didn't try than for the protocol describing the student with low ability.

22 *A comparison of student feedback obtained from three methods of formative evaluation of instructional materials*, 17(1988), 3–27 Medley-Mark, V. & Weston, C. B.

The success of formative evaluation techniques to improve instructional materials is well documented, but there is a paucity of research comparing the types of data obtained. This study compares the quantitative and qualitative nature of the problems identified by students in three conditions: one-to-one active; a small group active; and a small group passive. Explanations for the observed differences are attributed to and described in terms of the instructional materials themselves and differences in the procedures or conditions employed.

23 *Confronting misconceptions in the domain of simple electrical circuits*, 17(1988), 29–55
Brna, P.

This paper starts from the assumption that learning is promoted through confronting students with the inconsistencies entailed by their own beliefs. The issue is explored in the domain of electricity in the context of simple DC circuits. Previous work is used as the basis for the construction of a programme of work that is undertaken by a group of students, which entailed the development of a computer-based modelling environment. The results derived from observation suggest that computer-based modelling facilities can provide advantages over approaches exploiting other media.

24 *Reasoning and the structure of knowledge in Biochemistry*, 17(1988), 57–76 Ploger, D.

This study examines three aspects of reasoning in biological science. A methodology for explicitly describing biochemical knowledge is developed and applied to transcripts of reasoning to infer reasoning strategy from the way subjects use that knowledge; and two strategies are described. The results suggest that in problem solving, experts use a greater variety of strategies than novices, and in the explanation, experts use a more general form of the normal-function strategy than novices.

25 *CAI versus paper and pencil – discrepancies in students' performance*, 17(1988), 77–96
Hativa, N.

Differences were identified in students' performance of similar arithmetic tasks in two media: paper-and-pencil and computer-assisted instruction. Performance of elementary school students using pencil-and-paper was compared with their performance in CAI work in two widely used CAI systems; in two types of practice; with two types of task arrangement; and with two criteria. Results show that the majority of students performed better using pencil-and-paper than in the simultaneous CAI work, although there were students who achieved the opposite results for tasks arranged in a loose hierarchy. These contradictory trends are discussed and explained.

26 *An analysis of guidelines for expert reviewers*, 17(1988), 101–128 Saroyan, A. & Geis, G. L.

Forty eight sets of recommendations identified by their authors as practical heuristics for the evaluation and revision of instructional materials were reviewed and consolidated. These guidelines were extracted from professional journals, book chapters, and independent publications. Items were sorted into three categories according to their specific focus: content (subject matter), design, and presentation. In a second sort, identical items were eliminated, and semantically equivalent items were grouped together. Three independent judges per formed the same tasks for reliability. The outcome is a comprehensive list of 67 items, representing all of the reviewed guidelines. This instrument could be a successful aid in identifying deficiencies of instructional materials in the areas of content, design, and presentation.

27 *Analogical instruction within the information processing paradigm: effective means to facilitate learning*, 17(1988), 129–144 Stepich, D. A. & Newby, T. J.

Research on the structure of memory has led to evidence that relating unfamiliar information to that which is familiar facilitates the new material's acquisition and retention; moreover, such associations can be efficiently achieved through the use of analogies. The present paper discusses the current information processing conceptualization of memory, the processes of learning by analogy, and the overall desired outcomes of their use to acquire and retain new information. Additionally, instructional implications of how, when, and why to use analogies are discussed.

28 *Verbal and spatial encoding of text*, 17(1988), 145–157
Dickson, L. A. S., Schrankel, P. S. & Kulhavy, R. W.

Two experiments were conducted which examined conjoint retention of spatial and verbal information in memory. Experiment one examined processing of text with simultaneous active dual coding. With spatial and verbal information from experiment one, experiment two examined the effects of introducing dual coding prior to text processing and keyed recall to what was encoded prior to reading. Recall of both concrete features and events referring to these features was keyed to constructive encoding processes. Even minimal cueing produced better recall than no cues. Spatial primers produced not only better recall of features, but subjects who encoded spatial primers demonstrated increased ability to recall those primers. Results were interpreted in terms of dual coding theory for encoding and retrieval.

29 *The motive/strategy model of learning processes: some empirical findings,* 17(1988), 159–168 Watkins, D.

The motive/strategy model underlying the learning process inventories of both Biggs and Entwistle has major implications for both educational practice and research. As yet, however, there is only limited empirical support for the validity of the model. This paper reports findings, several as yet unpublished, from a number of the writer's investigations which throw light on this issue. Overall, these results question the validity of the model and fail to confirm several plausible propositions based on the model.

30 *When is a science analogy like a social studies analogy? A comparison of text analogies across two disciplines,* 17(1988), 169–177 Curtis, R. V.

This textbook survey analyzes the construction and use of analogies in social science texts and compares the results to an earlier analysis of physical science texts. Although the results indicate that the categories in the Curtis and Reigeluth classification system for analogy construction were consistent across disciplines, several differences were revealed related to how and when the analogy is used as an instructional design strategy.

31 *Generalising language-tutoring systems: a French/Spanish case study using LINGER,* 17(1988), 251–285 Yazdani, M. & Uren, J.

This paper describes our experiences in trying to extend a language tutoring system, LINGER, to deal with Spanish. LINGER is based on Definite Clause Grammar (DCG) notation. Unlike traditional language-teaching systems, it incorporates "human-like" knowledge of the domain it is teaching. Experiences in modifying such systems are relevant both to language teaching and to attempts at turning tutoring systems designed for specific tasks into tools capable of greater generality and use.

32 *Fragments: the implications for teachers, learners and media users/researchers of personal construal and fragmentary recollection of aural and visual messages,* 17(1988), 195–218 Mason, J. H.

A theory is advanced which proposes that when experience is recalled, it is recalled in fragments. The fragments are then woven together to make a story about the experience, which is what is often called construal, or making sense. There are manifold implications of the theory: in the design of instruction which explicitly employs the theory in the ways in which students are invited to work on materials in different media; for assessment which explicitly calls upon fragment processing skills; for research into the effective use of educational media.

33 *The interrelations between diagrammatic representations and verbal explanations in learning from social science texts,* 17(1988), 219–234 Guri-Rozenblit, T. S.

This study examined the instructional effectiveness of abstract diagrams and verbal explanations in learning from social science texts. Each text appeared in four versions, in which the verbal and schematic representations were manipulated. The main results indicate that: an explained diagram is more effective than an unexplained one in complex explanations; a diagram, in general, is more effective than a verbal explanation in representing sequential and hierarchical relations; a diagram has a significant effect on 'active' recollection and 'passive' retention; the mode of the text's design and presentation is more influential than the initial verbal and visual aptitudes; and finally, there are no differences between male and female in processing verbal and diagrammatic representations.

34 *The pedagogical limitations of generative student models,* 17(1988), 235–250 Laurillard, D.

Intelligent Tutoring Systems have three key aspects: the knowledge representation, the student model, and the teaching strategy. The focus of this paper is the student model – that part of the system that builds up knowledge about each student from their performance and uses it within a general description of student behaviour to enable the system to adapt to that individual. In this paper I examine how well the idea of a student model meets students' likely learning needs.

35 *Learning about forces simulating the outcomes of pupils' misconceptions,* 17(1988), 251–261 Finegold, M. & Gorsky, P.

We have developed a computer program which simulates the outcomes of pupils' perceptions regarding the forces at play in static equilibrium. A pupil is presented with a simulation of his or her own private microworld which may or may not be compatible with familiar behaviour in the real world. The program includes a tutor which helps the pupil learn the relevant scientific concepts if he or she cannot solve the problem without help.

36 *Applying artificial intelligence insights in a CAI program for 'open sentence' mathematical problems in primary schools,* 17(1988), 263–276 Barnard, Y. F. & Sandberg, J. A. C.

Elementary school children are often unclear which operations to use when tackling mathematical problems of the "open sentence" kind. We give details of some of their "impasse-repair" and other problem-solving strategies; computer models of knowledge and misconceptions underlying those strategies; and a CAI program which can identify strategies and remedy gaps in knowledge and misconceptions. Tests of that program with second graders in five schools over six weeks indicate that one third profited significantly. The results are further discussed.

37 *Skill-oriented task sequencing in an intelligent tutor for basic algebra,* 17(1988), 281–307 McArthur, D., Stasz, C., Hotta, J., Peter, O. & Burdorf, C.

In this paper we present an approach to task sequencing that is based on a component-skills view of intelligence and learning. We postulate that tutors use inferences about past and present student performance to determine a current skill set that will be the new target for learning. The skill set is then used as a basis for generating tasks that should elicit those skills. Current skill sets are modified slowly over time so that lessons appear coherent and well-planned. We first describe the approach at a general level, where it can be viewed as a cognitive model of human task sequencing. Then we discuss the implementation of the model in our intelligent algebra tutoring system.

38 *Beyond the logic of things: contextual effects on understanding and solving word problems,* 17(1988), 309–338 Reusser, K.

Arguments are put forward in this paper that classroom word problem solving is more – and also less – than the urgent analysis of a factual structure, in the sense that it is essentially a species of a social-cognitive activity. The present paper discusses the results of several studies showing, for example, that subject matter related attitudes towards a problem frequently do not play an important part in the problem solving efforts; that students often solve problems correctly without understanding them; and that false contextual expectations can lead to abstruse errors of understanding and to peculiar solution attempts. It is argued that the deeper reason for the observed textual and contextual influences on understanding and problem solving lies in a fundamental weakness of the student's epistemic control behavior. The psychological and instructional significance of the studies is discussed.

39 *The development of the representation of conceptual knowledge in memory and the design of instruction,* 17(1988), 339–350 Dijkstra, S.

Knowledge comprises facts, concepts and principles. Skills are categorized as either cognitive or motor skills, which are essential for solving problems. The acquisition of knowledge and skills is guided by instructions and by presenting problems to students. Firstly, the instructions for acquiring concepts, based on principles, are discussed and a model for teaching is presented. Further, the integration of class and relational concepts, together with principles, is shown to be necessary for solving problems.

40 *Teaching for learning-to-learn: a critical appraisal with some proposals,* 17(1988), 351–367 Klauer, K. J.

The recent literature on learning-to-learn is reviewed from the aspect of how to improve learning activities. Focus is on questions such as the appropriate dependent variable, the most promising variables to practise and particularly the diverse learning strategies to teach to students. Other questions dealt with are the kind of curriculum and the optimal breadth of the interventional program. The main proposal is that teachers should be qualified not only to teach the respective subject matter but also to teach students how to learn this subject matter.

41 *Linking cognitive learning to instructional prescriptions,* 17(1988), 369–385 Tennyson, R. D. & Rasch, M.

This article presents an initial model of instructional design which directly links cognitive learning theory and instructional prescriptions. The major constructs of the model include components of the memory system, allocation of learning times by objectives and specific instructional methods. The model proposes that instructional time be divided so as to reach the educational goals of improvements in higher-order learning and thinking as well as knowledge acquisition. Integrating current methods of instructional strategies provides the framework for bridging the gap between cognitive learning theory and instructional design.

42 *Some reflections on thinking skills,* 17(1988), 387–390 Gagné, R. M.

This paper is based upon a 1987 symposium of the American Educational Research Association: Metalearning theories and instructional design. This paper poses the question "Are there any thinking skills?", then considers points that need to be taken into account in arriving at a reasonable answer to this question. It concludes "There is thinking, and there are skills. But – are there any thinking skills?".

43 *Hypertext for structuring a conceptual design for computer-assisted language learning,* 18(1989), 5–26 Swartz, M. L. & Russell, D. M.

A compelling problem for language pedagogues is teaching foreign languages to students so they can retain and use the language skills in real communicative situations. One way to help students learn these skills is to understand and improve current pedagogical approaches to language learning. New technology such as Computer-Assisted Language Learning (CALL) provides pedagogues with rich, multimedia environments for presenting instruction. At the same time, deciding what to present and how to organize the instruction in CALL provides a new challenge. In response to this problem, we discuss preliminary results of a research effort for developing an instructional design environment (IDE) that is uniquely tailored to the needs of developing foreign language instruction. Hypertext features in the IDE software are used to capture and organize into one coherent framework the corpora of theoretical, instructional, and content material that affects foreign language instruction.

44 *An intelligent tutoring system for helping children aged 7 to 15 to acquire a second language,* 18(1989), 27–43 Button, C. G.

Traditional approaches to teaching a foreign language in Artificial Intelligence (AI) systems restrict the computer to correcting grammar or vocabulary; this is similar to structural teaching strategies (STS) in which a second language (L2) is learned in relation to a first language (L1). By contrast, this paper suggests that the role of a computer tutor in language learning need not necessarily be confined to that of a foreign language expert. It investigates ways in which to represent both the learner's L2 skills and the foreign language expert. These lead to a novel computational method for teaching a foreign language, suitable for children aged 7 to 15.

45 *Some uses of natural language interfaces in computer assisted language learning,* 18(1989), 45–61 Ward, R. D.

It has often been proposed that computer programs simulating written conversation could be effective in language teaching and remediation. This paper presents a theoretical rationale for this approach, and reports empirical studies of its potential. Although the studies were concerned mainly with language-impaired children, their findings should have some relevance for the wider field of computer assisted language learning in general. The paper concludes with suggestions about how these ideas might form the basis of future intelligent tutoring systems able to prescribe a variety of language learning activities, over a range of language materials.

46 *ALICE: acquisition of linguistic items in the context of examples,* 18(1989), 63–92 Cerri, S. A.

Most natural language terms – such as verbs, nouns, conjunctions, prepositions – have a context-dependent meaning. The dependence of the meaning on the context changes with languages. This variability accounts for many errors made by students while learning a foreign language. ALICE is an interactive system which relies on a pragmatic representation of conceptual differences of linguistic terms in several languages (currently, subordinate conjunctions in English, French and Italian) and offers diagnostic and remedial strategies for mistakes made by a student in translating from or into any of the available languages.

47 *SPELT (Strategies Program for Effective Learning/Thinking): a description and analysis of instructional procedures,* 18(1989), 95–118 Peat, D., Mulcahy, R. F. & Darko-Yeboah, J.

The SPELT instructional model is examined in terms of current instructional design principles. The goal of this analysis is to determine the extent to which the design of the SPELT instructional model conforms to proven instructional procedures. It is revealed that parts of the SPELT instructional model, with its three methodologies, are consistent with theory and/or empirical findings of early scramble studies, Bruner's spiral curriculum, Ausubel's progressive differentiation, and Gagné's hierarchical sequencing. Although not empirically validated, Reigeluth and Stein's Elaboration Theory offers the best overall descriptive analysis of the SPELT instructional model.

48 *Formative assessment and the design of instructional systems,* 18(1989), 119–144 Sadler, D. R.

The theory of formative assessment outlined in this article is relevant to a broad spectrum of learning outcomes in a wide variety of subjects. Specifically, it applies wherever multiple criteria are used in making judgments about the quality of student responses. The theory has less relevance for outcomes in which student responses may be assessed simply as correct or incorrect. Feedback is defined in a particular way to highlight its function in formative assessment. Three conditions for effective feedback are then identified and their implications discussed. A key premise is that for students to be able to improve, they must develop the capacity to monitor the quality of their own work during actual production.

49 *The study of teachers' written feedback to students' writing: changes in theoretical consideration and the expansion of research contexts,* 18(1989), 145–165 Zellermayer, M.

This paper identifies four successive phases in the study of written feedback to students' compositions. The studies included in these phases are distinguished by views of writing instruction reflected in their theoretical frameworks. While reviewing recent studies of written feedback, the paper shows how these changing views of writing instruction are accompanied by changing theoretical perspectives for the study of the provision and processing of written feedback as well as by a gradual expansion of research contexts for looking at this problem. Finally, in view of such a line of development, it suggests an agenda for future research.

50 *Solving the learning paradox,* 18(1989), 169–177 Lawson, A. E. & Staver, J. R.

If the constructivist doctrine that complex cognitive structures are actively constructed by the learner is accepted, a key question arises. How can a simple structure generate another more complex structure? As current constructivist theory offers no satisfactory answer to this question, we are left with what has been called the "learning paradox". We offer here a theoretical solution of the learning paradox by suggesting that complex cognitive structures which guide behaviors with novel emergent properties arise from combinations of simpler structures in a way analogous to the way phenomena with emergent proprieties arise in the natural sciences. Grossberg's neural modeling principles of learning are discussed as a way in which more complex neural networks arise spontaneously from combinations of simpler neural networks when given normal environmental stimulation, thus showing how the learning paradox can be solved.

51 *Teaching for analogical transfer as a means of improving problem-solving, thinking and learning,* 18(1989), 179–192 Klauer, K. J.

Analogical transfer is transfer of a basic structure acquired through one or more instances to another instance. A basic structure like this is sometimes called a paradigm. Paradigmatic teaching, i.e. teaching for analogical transfer, requires the teaching of a basic structure by appropriate exemplars as well as the teaching of its application in various fields and contexts. This is demonstrated using research on teaching for problem-solving, inductive thinking, and learning-to-learn.

52 *Designing a self-improving tutor: PROTO-TEG,* 18(1989), 193–216 Dillenbourg, P.

This paper presents the principles and the architecture of PROTO-TEG, a self-improving tutor in geometry. This system is able to discover criteria useful for selecting the didactic strategies it has at its disposal. These criteria are expressed as characteristics of the student model. They are elaborated by comparing student model states recorded when a strategy was effective and those recorded when the same strategy was not effective. This comparison is performed by machine learning methods, or, more precisely, by learning concepts from examples. An empirical experiment was performed in order to assess the self-improving functions; conditions were discovered for five of the nine didactic strategies. However, this new knowledge did not lead to PROTO-TEG being more efficient in terms of student performance.

53 *A more equitable account of the note-taking function in learning from lecture and from text,* 18(1989), 217–232 Kiewra, K. A., Dubois, N. F., Christensen, M., Sung-Il, K. & Lindberg, N.

Previous research investigating the encoding, encoding-plus-storage, and external-storage functions of note taking has failed to equate processing opportunities among the groups. The present study attempted to do so. Three forms of note taking were used: conventional, and note taking on skeletal and matrix frameworks. In lecture learning and in text learning, an advantage was found for the encoding-plus-storage function on tests involving factual-recall and recognition performance but not on tests measuring higher-order performance. With respect to note-taking forms, no advantage existed for any form when information was acquired from lecture. The findings were explained relative to observed note-taking behaviors, the opportunity for review, and the processing demands proposed by the combination of reading and note taking, particularly when notes must be classified into an existing framework.

54 *Overcoming misconceptions via analogical reasoning: abstract transfer versus explanatory model construction,* 18(1989), 237–261 Brown, D. E. & Clement, J.

In most work investigating factors influencing the success of analogies in instruction, an underlying assumption is that students have little or no knowledge of the target situation (the situation to be explained by analogy). It is interesting to ask what influences the success of analogies when students believe they understand the target situation. If this understanding is not normative, instruction must aim at conceptual change rather than simply conceptual growth. Through the analysis of four case studies of tutoring interviews (two of which achieved some noticeable conceptual change and two of which did not) we propose a preliminary list of factors important for success in overcoming misconceptions. The result of this process may need to be more than analogical transfer of abstract relational structure. The analogies may need to be used to enrich the target situation, leading to the student's construction of a new explanatory model.

55 *A model of student approaches to learning encompassing ways to influence and change approaches,* 18(1989), 263–288 Kember, D. & Gow, L.

The terms surface and deep are widely used to describe student approaches to studying and learning. Different writers have attributed different shades of meaning to the terms, as the categories have resulted from the work of a number of groups or individual researchers. There are greater divergences of opinion on the question of how students can be influenced to adopt either surface of deep approaches. The model recognises the existence of predispositions to either deep or surface approaches, and the use of strategies for particular tasks. A number of contextual variables seem to influence students with a deep predisposition to adopt surface strategies. The transition between surface and deep predispositions is seen as difficult to influence, but three types of intervention are discussed.

56 *Instructional behaviors for clearer presentations in the classroom,* 18(1989), 289–314 Chilcoat, G. W.

Teachers spend a considerable amount of classroom time talking to students. Much of this talk revolves around expository presentations of information. Teachers claim the reason for the quantity of teacher talk is to clarify instruction to students. However, discrepancies can exist between what teachers assume are the benefits of their talk and how students learn from such talk. To match students' abilities to learn, teachers must produce clearer instructional presentations. This article proposes the importance of structure in developing sound teacher expository presentations. Nine instructional behaviors based on correlational and experimental research during the past two decades are presented in the form of teacher guidelines to maximise precision and structure in teacher talk in order to facilitate student achievement.

57 *Assimilatory tools for informal learning: prospects in CAI,* 19(1990), 3–9 Duchastel, P.

Based on the distinction in cognitive psychology between accommodation and assimilation (restructuring of cognitive structure vs incorporation within one's cognitive structure), an analytical distinction is made in ICAI between two general types of cognitive tools: power tools which augment cognition of a structural nature, and assimilatory tools geared to information acquisition. The distinction may have practical suggestive value in the design of ICAI applications, and theoretical value in the concrete form of the "learning task/control" hypothesis, whereby power tools involving strong tutorial intervention are more appropriate for accommodation learning tasks, and assimilatory tools are more appropriate for tasks involving associational learning, where greater learner control is desirable.

58 *Intelligent educational systems: identifying and decoupling the conversational levels,* 19(1990), 11–27 Cumming, G. & Self, J.

Intelligent educational systems (IESs) have traditionally been thought of in terms of their functional subsystems. We argue that it is useful to reconceptualise IESs: we should think of them from the point of view of the multiple levels of conversational interaction that they support with a learner. We suggest that in many cases it is useful to identify a task level at which the learner is working, and a higher discussion level at which the learner and system converse about, and reflect on the primary task. If the two levels can be to some extent decoupled, meaning that each level has less than complete knowledge of the other level, IES development might be simplified. A critical requirement for a decoupled IES is a representation for communication between levels; study of human tutoring is needed to guide identification of suitable representations.

59 *Concept maps and Vee diagrams: two metacognitive tools to facilitate meaningful learning,* 19(1990), 29–52 Novak, J. D.

This paper describes two metacognitive tools, concept mapping and Vee diagramming, and reports on research utilizing these tools from grades one through university instruction. The psychological and epistemological foundations underlying these tools is presented briefly. The issues of the dominantly rote-mode nature of much school learning and the resistance of students (and teachers) to move to meaningful learning strategies fostered by concept mapping and Vee diagramming are discussed. The data available to date from a variety of qualitative and quantitative research studies strongly support the value of these metacognitive tools both for cognitive and affective gains.

60 *Some implications of cognitive theory for instructional design,* 19(1990), 53–69 Winn, W.

This article examines some of the implications of recent developments in cognitive theory for instructional design. It is argued that behavioral theory is inadequate to prescribe instructional strategies that teach for understanding. Examples of how instructional designers have adopted relevant aspects of cognitive theory are described. However, the growing body of evidence for the indeterminism of human cognition requires even further changes in how instructional designers think and act. Three implications of cognitive theory for design are offered: instructional strategies need to be developed to counter the reductionism implicit in task analysis; design needs to be integrated into the implementation of instruction; designers should work from a thorough knowledge of theory not just from design procedures.

61 *Comprehending instructions for using pharmaceutical products in rural Kenya,* 19(1990), 71–84 Patel, V. L., Eisemon, T. O. & Arocha, J. F.

This paper reports two studies on comprehension of pharmaceutical texts containing pictorial and written instructions by mothers in rural Kenya. Mothers recalled the procedures for the preparation as in the pictures but not those presented in the written instructions. Written instructions were generally found to be difficult, with the original text being more difficult than the revised text. Any conflicting information between written and pictorial instructions was resolved by selecting the familiar procedure. The information recalled from the revised text that was recalled was that which supported the procedures in the pictures. The results have implications for writing adequate pharmaceutical texts for users such that little room is left for misinterpretation.

62 *The ADAPT design model: towards instructional control of transfer,* 19(1990), 89–120 Jelsma, O., van Merriënboer, J. G. & Bijlstra, J. P.

This paper presents a detailed description of the ADAPT (Apply Delayed Automatization for Positive Transfer) design model. ADAPT is based upon production system models of learning and provides guidelines for developing instructional systems that offer transfer of learned skills. The model suggests that transfer of training can be attributed to procedure overlap between the original training task and the transfer task, as well as to analogy between new problem solving situations and acquired cognitive schemata. The relevance of ADAPT is evaluated and implications for future research are presented.

63 *The Instructional Design Environment: technology to support design problem solving,* 19(1990), 121–144 Pirolli, P. & Russell, D. M.

The problems of efficiently producing effective instruction are exacerbated by several complex factors: increasingly rapid change in technology; substantial variation in training needs and target populations within large organizations; inefficient mechanisms for performing formative evaluations; and a lack of means for efficiently incorporating new models of design into practice. In the context of these increasingly difficult problems, we present the Instructional Design Environment (IDE), a hypermedia system for designing and developing instructional material, including texts, interactive video disk, and intelligent tutoring systems. The representation of design analyses and specifications, and the design activities of IDE users are not constrained by any particular model of instructional design, but can be tailored to suit a wide range of such models. Although the system is continually evolving and exists in several forms, we discuss how the features of IDE suggest how computer-based design environments may provide ways simplifying the design problems for technical training in rapidly changing areas.

64 *Building electronic communities: success and failure in computer networking,* 19(1990), 145–169 Riel, M. & Levin, J. A.

This paper is about networking failures and networking successes. A research strategy for comparing educational activities conducted across electronic networks was employed to examine the critical features of successes as well as failures in designing electronic communities. The analysis provides a set of guidelines for those who plan to use telecommunications as a tool for creating global communities.

65 *Generated meanings in the comprehension of word problems in mathematics,* 19(1990), 171–206 Peled, Z. & Wittrock, M. C.

A "Generative-Predicational Model" is proposed and applied to the generation of meanings of simple mathematical word-problems. The model suggests that a fundamental property of cognition is a generative process that takes arguments and that produces results, such as events, answers and inferences. This fundamental property, called predication, generates a task-environment i.e., a problem and its corresponding problem-space i.e., its solution. More precisely, a task-environment is a predication consisting of a written mathematical problem and a writer's life experience. A problem-space is a predication consisting of a learner's problem solving schema and of the meaning that the learner generates for the text. The ease with which relations can be established between a task-environment and a problem-space depends on the problem's "coherence" and "complexity" and the learner's experiences and thought processes. Faceted definitions of task-environment and problem-space are used to analyze talk-aloud protocols of fifty Israeli sixth-graders tested with thirty word-problems. The empirical results support the proposed model.

66 *Effects of processing instructions on the usefulness of a graphic organizer and structural cueing in text*, 19(1990), 207–217 Bernard, R. M.

This study assessed two adjuncts to instructional text, structural cueing and graphic organizer processing instructions. Previous research has shown that cueing is a useful indicator of textual structure and that graphic organizers can be enhanced by providing learners with an indication of how they can be used. Results indicated the presence of a three-way interaction among reading ability groups, structural cueing and graphic organizer processing instructions. Analysis of this interaction revealed that high level readers were the only subjects who profited from processing instructions, and only in the presence of cueing. Middle level readers benefited from cueing in both conditions of processing instructions while low level readers were able to take advantage of cueing only in the absence of processing instructions. The results are interpreted in light of previous graphic organizer research.

67 *Mathematical problem posing: implications for facilitating student inquiry in classrooms*, 19(1990), 219–245 Yerushalmy, M., Chazan D. & Gordon M.

From 1984 through 1988, the authors worked with teachers using an inquiry approach to teach high school geometry courses with the aid of the GEOMETRIC SUPPOSERS. Problems are a critical component of the approach, because they focus attention and energy and guide students in the application, integration, and extension of knowledge. Inquiry problems differ from traditional, single-answer textbook exercises in that they must leave room for student initiative and creativity. The observations presented about the delicate balance between specifying too much instruction and too little, which is part of creating and posing inquiry problems, are based on careful examination of students' papers and classroom observations. The paper closes with speculations on whether these observations suggest general lessons for those seeking practical and successful strategies to introduce student inquiry into classrooms, with the hope of stimulating interest in and discussion of such strategies.

68 *Teaching, learning and using Prolog: understanding Prolog*, 19(1990), 247–256 Brna, P., Pain, H. & du Boulay, B.

Editors' introduction to the Special Issue: *Teaching, learning and using Prolog.*

69 *What's wrong? Understanding beginners' problems with Prolog*, 19(1990), 257–282 van Someren, M. W.

This paper reviews psychological research on programming and applies it to Prolog. We present a psychological model that explains how a certain class of errors in programs comes about. The model fits quite well with the results of a small sample of students and problems. The problems underlying these and other errors seem to be (a) the complexity of the Prolog primitives (unification and backtracking) and (b) the misfit between students' naïve solutions to a problem and the constructs that are available in Prolog (e.g., interative solutions do not map easily to recursive programs). This suggests that learning Prolog could be helped by (1) coherent and detailed instruction about how Prolog works, (2) emphasis on finding recursive solutions that do not rely on primitives such as assignment and (3) instruction in programming techniques that allow students to implement procedural solutions.

70 *Analysing novices analysing Prolog: what stories do novices tell themselves about Prolog?*, 19(1990), 283–310 Taylor, J.

Observations of Prolog learners showed that, despite being presented with correct information and models, they still tended to construct their own idiosyncratic explanations of events, and characteristically, defended these 'stories' fiercely when tutorial intervention was attempted. Although the stories were often so flawed that the student's future progress was potentially hampered, learning could not have proceeded without them. If we are to understand the novice Prolog programmer, we need to know about these stories, their source, and what, if anything, they have in common from one learner to another. Observational studies showed that students used tacit knowledge of human discourse processes both to interpret the language used to communicate with the computer and to interpret the behaviour of the machine. Students did not appreciate the fundamental differences between natural discourse and formal discourse and confused elements of the discourse levels. This can be an effective initial learning strategy, but unless its limitations are recognised, programs are inevitably incomplete at some level. Examples from these studies are reported here with illustrative protocol fragments.

71 *Towards a taxonomy of novices' misconceptions of the Prolog interpreter,* 19(1990), 311–336
Fung, P., Brayshaw, M., du Boulay, B. & Elsom-Cook, M.

A series of novice programmers' misconceptions of Prolog flow-of-control and variable unification are identified on the basis of existing empirical evidence and informal observation. This classification is intended to serve as a first pass attempt towards an understanding of these errors and as a basis for future empirical work.

72 *Redo 'Try once and pass': the influence of complexity and graphical notation on novices' understanding of Prolog,* 19(1990), 337–360 Hõok, K., Taylor, J. & du Boulay, B.

Various attempts have been made to describe novices' misunderstandings of flow of control in Prolog in terms of such misconceptions as 'Redo body from left' (RDBL) and 'Try once and pass'. These are useful descriptive terms but it is not clear how stable these misconceptions are nor why these particular ones arise rather than others. We argue that novices' behaviour is strongly influenced by the properties of the programs they work on, so that under some circumstances they may exhibit RDBL but at other times offer different (sometimes correct) accounts of control flow. Part of this apparent inconsistency can be explained in terms of novices' 'meta-analysis' of the program. To elucidate this notion of meta-analysis, we examine the influence of program complexity and the choice of names of predicates on novices' accounts of Prolog flow of control. We also compare graphical tree-based representations for Prolog execution with more textually oriented representations to see how this also influences novices' accounts of control flow.

73 *Understanding students' errors with Prolog unification,* 19(1990), 361–376
van Someren, M. W.

One of the mechanisms that a student of Prolog must learn to understand and to use is unification. Initially, students have only a partial understanding of unification and therefore they are not able to fully understand the execution of a program. This paper shows that a considerable part of the errors that students make can be explained by an impaired version of the correct algorithm. The changes from the correct algorithm to the false algorithms can be justified by a psychologically plausible mechanism.

74 *Principles for the design of dynamic tracing environments for novice programmers,* 19(1990), 377–406 Rajan, T.

This paper describes the principled design of a computational environment which depicts an animated story of the execution of programs for novice programmers. The design principles are aimed at solving the problems that novice programmers face when learning new programming languages, and are embodied in an Animated Program Tracer (APT) for Prolog. The goal of this research is to develop a more systematic, if not yet scientific, basis for the design of animated tracing tools.

75 *A fine-grained account of Prolog execution for teaching and debugging,* 19(1990), 407–436
Eisenstadt, M. & Brayshaw, M.

A clear and consistent execution model of any programming language can lay the foundations not only for a good learning experience, but also for a smoother design/edit/run/debug cycle. In this paper, we describe our attempt to construct precisely such a model for the logic programming language Prolog, based upon a notational extension of logic programming's traditional AND/OR trees. Our extension, called the AORTA diagram, is an And/OR Tree, Augumented to include invocation history 'status boxes' at each node. This augmentation makes it possible to present a graphical view of Prolog execution which is very compact, yet which contains complete details of unification and control history, including multiple (backtracking) invocations and extra-logical features such as the cut. The paper describes our fine-grained view of Prolog execution in detail, and argues that this fine-grained view can readily be integrated into a coarse-grained model such as that required for understanding the execution of very large programs. Indeed, our notation is already in use across a range of media, including textbook digrams, video animations, and a graphical tracing and debugging facility running on modern graphics workstations.

76 *Cognitive design for instructional design,* 6(1990), 437–444 Duchastel, P.

There is strong interest in the field of instructional design in building expert systems that can provide advice to inexperienced instructional designers. This paper questions whether the expert systems model to advice-giving is in fact appropriate for a design process such as instructional design. An alternate approach based on case-based reasoning and the critic approach to advice-giving is considered to be better adapted to the cognitive needs of this task. The cognitive constraints of the task are used to orient the design of an instructional design workbench. The concept of an ID workbench illustrates the direct application of cognitive science to a complex practical task in the area of design.

77 *Cooperative learning across classrooms in electronic Learning Circles,* 6(1990), 445–466 Riel, M.

This paper discusses electronic Learning Circles on the AT&T Learning Network in the light of cooperative learning theory. Findings reported for students in cooperative learning settings were also found for teachers who participated in Learning Circles on the Learning Network. Teachers acquired knowledge, developed new instructional strategies, increased their self-esteem and developed professional and personal relationships with their peers. Computer networking provides a mechanism for developing cooperative learning among students in distant locations and at the same time provides a vehicle for the professional development of teachers within the classroom environment.

78 *The clinical use of motivational messages: an inquiry into the validity of the ARCS model of motivational design,* 6(1990), 467–500 Visser, J. & Keller, J. M.

Instruction, even when prepared according to sound instructional design principles, often does not stimulate students' motivation to learn. A motivational intervention, developed according to the processes outlined in the ARCS model of motivational design, was implemented and tested following the conventions of an embedded single-case study. It was tested with a group of 15 adults participating in a staff development course conducted within the Mozambique Ministry of Education. Results, based on concurrent and discriminant analysis of both quantitative and qualitative data, indicated that the primary treatment, motivational messages, had positive effects on student attitude and performance. It may be concluded that the specific intervention and the ARCS model which provided the basis for designing it provide a sound basis for positively influencing student motivation to learn.

79 *Mediating the message: television programme design and students' understanding,* 20(1991), 3–23 Laurillard, D.

The research reported represents a non-standard approach to basic research on educational television, in that it uses qualitative methods to describe learning and to illuminate which programme features are important. It was based on observation, interview and test data from five groups of 20-30 Open University students, each watching a social science television programme as part of their course. A qualitative analysis of students' summaries of the programmes showed that only half achieved the intended learning outcomes. A further analysis of the students' responses to key extracts showed that this is more likely to be because of programme structure than because of presentational quality. The research design and results are related to similar studies on students learning from text.

80 *Didactic use of concept mapping in higher education: applications in medical education,* 20(1991), 25–47 Mahler, S., Hoz, R., Fischl, D., Tov-Ly, E. & Lernau, O. Z.

This paper describes the use of concept mapping for didactic purposes in higher education at the university level, namely, in medical schools. The first study involved the use of concept mapping to evaluate students' self learned knowledge of subject matter during their clerkship in a department of surgery. The individually constructed cognitive maps facilitated learning by being used in group discussions with the tutor, to identify correct ideas as well as misconceptions, and to convey the tutor's view, and thereby facilitated learning. The second, unrelated study employed concept mapping to evaluate an inservice Orientation Workshop for medicine school faculty. The cognitive structure characteristics of the participants and their congruence with those of the workshop teachers were assessed. These provided evidence regarding the attainment of the workshop's objectives for different kinds of participant. Potential didactic uses in higher education are discussed in light of these studies.

81 *The computer as tutor: can it adapt to the individual learner?*, 20(1991), 49–78
Hativa, N. & Lesgold, A.

Educational literature indicates that computers have not yet completely fulfilled the promise for systematic individualization of instruction. We offer here a partial explanation for this, based on observations of elementary school children doing computer-managed drill and practice in arithmetic in four different CAI systems. A general model for adaptation of instruction to the learner, using computerized management of practice, is presented. Our data show that the key elements of this process – the software-based students' evaluations and the subsequent decisions – are sometimes inaccurate or even totally wrong and result in presentation of inappropriate material or feedback to the learner. We suggest the incorporation of human teachers into the evaluation and decision-making process.

82 *Teaching, learning and using Prolog: supporting the programmer*, 2/20(1991), 81–87
Brna, P., Pain, H. & du Boulay, B.

Introduction to the second part of a double Special Issue: *Teaching, Learning and Using Prolog.*

83 *An evaluation of APT: an Animated Program Tracer for novice Prolog programmers*, 20(1991), 89–110 Rajan, T.

This paper describes an approach to evaluating the usefulness of an Animated Program Tracer (APT) in communicating run-time information to novice Prolog programmers. The method used in the evaluation consists of a set of programs which have been specially designed to elicit how novices think Prolog programs are executed, and thus to reveal how accurate their model of program execution is. Two experiments are reported. The first determines the misconceptions that novices hold about the runtime actions of the Prolog interpreter, and produces six different categories of misconception. The second experiment investigates the ability of APT to communicate run-time information to novice Prolog programmers. A scoring technique was used to interpret subjects' answers, and shows that there was a significant improvement in the scores of the group who saw programs traced by APT when compared with a control group who saw no trace.

84 *Prolog programming techniques*, 20(1991), 111–133 Brna, P., Bundy, A., Dodd, A., Eisenstadt, M., Looi, C.-K., Pain, H., Robertson, D., Smith, B. & van Someren, M. W.

In this paper we introduce the concept of a Prolog programming technique. This concept is then distinguished both from that of an algorithm and that of a programming cliché. We give examples and show how a knowledge of them can be useful in both programming environments and in teaching programming skills. The extraction of the various techniques is outlined. Finally, we discuss the problem of representing techniques where we conclude that the most promising approach is the development of a suitable meta-language.

85 *A recursive techniques editor for Prolog*, 20(1991), 2135–172
Bundy, A., Grosse, G. & Brna, P.

We describe an editor geared to recursive Prolog procedures. It is similar to the structure editors built for many programming languages, except that instead of just ensuring the correctness of the syntax of the procedures built by the editor, the editor also ensures the correct use of recursion. By correct here we mean that the recursive procedure is guaranteed to terminate and to be well-defined. Within these constraints we have tried to ensure that the range of procedures that can be built is as complete as possible.

86 *Learning Prolog in a schema-based invironment,* 20(1991), 173–192 Gegg-Harrison, T.

A set of basic construct Prolog schemata are presented as the basic constructs of a structured Prolog for recursive list processing. Prolog schema hierarchies are given that group classes of Prolog programs within each of the basic construct Prolog schemata via most-specific schemata which highlight their similarities and differences. A schema-based instructional approach based upon this classification of Prolog programs is provided as a method of introducing recursion to novice Prolog programmers. The incorporation of this approach to teaching recursive Prolog programming in an intelligent tutoring system is presented. Finally, a schema-based Prolog programming environment embedding this tutoring system in addition to a standard Prolog development system is proposed which promotes the acquisition and use of structured programming constructs in Prolog.

87 *An overview of Prolog debugging tools,* 20(1991), 193–214
Brna, P., Brayshaw, M., Bundy, A., Elsom-Cook, M., Fung, P. & Dodd, A.

In this paper we present an overview of the advances in debugging standard Prolog programs. The analysis offered is in terms of a classification of tools that provide different degrees of activity in the debugging process. Other possible dimensions of analysis are also outlined.

88 *Automatic debugging of Prolog programs in a Prolog Intelligent Tutoring System,* 20(1991), 215–263 Looi, C.-K.

This paper describes an approach to the debugging of student Prolog programs in a Prolog Intelligent Tutoring System (PITS) that detects errors in them and proposes the corrections necessary to fix them. It proposes the use of multiple sources of expertise to analyse Prolog programs for tutoring purposes, and the collaboration of these sources for understanding student programs, detection of bugs and suggesting fixes to buggy student programs. It also demonstrates the use of a heuristic best-first search of the program decomposition space to parse a Prolog program into a hierarchical structure of predicate definitions, clauses, subgoals, arguments and terms. This article illustrates the merits of an algorithm-based approach supplemented by multiple sources or expertise for program debugging by showing that APROPOS2 is an effective, realistic and useful tool for program debugging. It then highlights the difficulties inherent in debugging Prolog programs and discusses the limitations of our algorithm-based approach.

89 *The cognitive effects of a mathematics in-service workshop on elementary school teachers,* 20(1991), 267–288 Bart, W. M. & Orton, R. E.

Siegler's rule assessment methodology was used to investigate the cognitive effects of a 32 hour mathematics in-service workshop on 28 elementary school teachers. This paper reports on attempts (a) to assess the levels of cognitive understanding of the basic concepts of proportion, probability, and correlation among elementary teachers, and (b) to change teachers' levels in understanding these concepts by a method of "direct instruction". Significant improvements were noted in the levels of cognitive development associated with the concept of proportion. Though nonsignificant improvements were noted in the concepts of probability and correlation, all the teachers were assigned to the highest cognitive rule associated with the probability concept at the end of the workshop.

90 *Instructional design for meaningful learning,* 20(1991), 289–310 Kember, D.

The instructional design and student learning literature is reviewed for guidelines for instruction which would encourage deep rather than surface learning. A taxonomy is presented which values student conceptions of key phenomena and skills for the self-discovery of knowledge as more important than the accumulation of information. Strategy elements suggested for the selection and sequencing of content, therefore, focus on revealing the interrelationship between key concepts. Evidence is presented of the persistent nature of existing conceptions and the difficulty of changing conceptual frameworks. Diagnostic questions are suggested as a means of exposing existing conceptions. It then seems necessary to provide a challenge to revealed or anticipated misconceptions so that students pass through a disequilibrium phase before re-forming their existing conceptions. As there is growing evidence of a mis-match between the goals and practice of teachers, action research is suggested as a method of implementation.

91 *Evaluation of students' strategies for concept application in engineering design,* 20(1991), 311–329 Samuel, A. E. & Lewis, W. P.

The article presents the results of an educational experiment in evaluating the strategies and 'microstructure' of student thinking in the application of domain specific concepts in engineering design at the University of Melbourne. This work is related to previously reported propositions in educational theory. It is found from the Melbourne experience that the compartmentalized domain specificity of engineering science learning, and by corollary the learning programmes in secondary schools, adversely affect the robustness of concept formation in engineering design. It is also conjectured that fluency in concept use as well as flexibility in crossing boundaries of knowledge domains is an essential trait of effective engineering designers.

92 *Does confidence in the language of instruction influence a student's approach to learning?,* 20(1991), 331–339 Watkins, D., Biggs, J. & Regmi, M.

The effects of the language medium of instruction on students' approaches to learning has been little researched, despite its obvious importance in cultures that use second-language instruction. Existing research is counter-intuitive, associating deep approaches with bilinguality, not surface. Confidence in one's competence in the L2 medium is suggested to be an important moderating variable. Two studies were conducted (1) involving Hong Kong University students, and (2) Nepalese high school students. Both suggested that language confident students were low on surface and high on deep approaches, as might be expected. Relations with achievement motivation however varied between the two cultures.

Book reviews

R1 Barth, R. P. *Social and cognitive treatment of children and adolescents: practical strategies for problem behaviours,* 16(1987), 102 — Tipper, E

R2 Boud, D. Dunn, J. & Hegarty-Hazel, E. *Teaching in laboratories,* 17 (1988), 191 — Evans, D.

R3 Daloz, L. *Effective teaching and mentoring – realizing the transformational power of adult learning experiences,* 17 (1988), 97 — Zimmer, B.

R4 Dijkstra, S., van Hout Wolters, B. H. A. M. & van der Sijde (Eds.), *research on instruction: design and effects,* 19 (1990), 345 — Park, O.

R5 Foster, D. & Lock, R. (Eds.) *Teaching science 11-13,* 17 (1988), 278 — Head, J.

R6 Heerman, B. *Teaching and learning with computers: a guide for college faculty and administrators,* 18 (1989), 233 — Jones, A.

R7 Hodgson, B. & Scanlon, E. *Approaching primary science,* 16 (1987), 101 — Shipstone, D.

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R11 Lindsey, C. W. *Teaching students to teach themselves,* 18 (1989), 315 — Zimmer, B.

R12 Mandl, H., de Corte, E., Bennett, S. N. & Friedrich, H. F. (Eds.) *Learning and instruction – European research in an international context,* 19 (1990), 501 — Lefrère, P.

R13 Mason, R. & Kaye, A. *Mindweave: communication, computers and distance education,* 19 (1990), 85 — Colbourn, C. J.

R14 Oosthoek, H. & Vroeijenstijn, T. (Eds.) *Higher education and new technologies,* 19 (1990), 501 — Lefrère, P.

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